AGRI-TECH THOUGHT LEADERSHIP PAPER

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Frugal innovation in the field

Innovation is required in order to feed the world.

Farmers across the globe need to become more efficient, use fewer resources and lower the labor burden. However, the margins in the farming business are small and continually squeezed by market pressures.

Although there is a strong case for deploying automation, monitoring and precision technologies to the field, we must be aware of the barriers to entry for the farm business; whether that be an initial cost or ongoing operational expenditure.

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This is good news for consumers across the globe as we attempt to reconcile the ever-growing demand for food (driven by population growth and in particular the increase of the defined middle classes in many developing economies) with challenges on land use, climate change concerns or dwindling access to low-cost labor.

However, many innovations – and the products they become – rarely offer a cast-iron guarantee of success or return on investment. In a market where one bad year could destroy a generations'-long business, the priority for investing in high-cost, long-term technology is likely to be low on the list.

Therefore, as product developers, we must better understand the needs of – and drivers for – the farmer on the ground and consider how to design technology which more immediately delivers improvements to the bottom line.

Diverse market of farmers

As we understand that there is no one archetypical farmer and no one archetypal farm, it's logical to see that the technologies and products are going to be inconsistently valuable and relevant. Therefore, what is suitable for a mega-ranch in Argentina is not going to be appropriate for deployment to an average UK cattle farm (mean herd size of 42 beef cows as at 2017)[1].

Put simply, different farms imply wholly separate requirements on the technology choices underpinning new product development. For example, the impact of local ground topology on communications methods, or the ability to guarantee uptime on cellular networks in remote / hilly locations, might be out of the control of the product developer and thus require a more creative solution.

It is possible to imagine a farm laborer changing the batteries on collars for a herd of 40 cows, but when the herd numbers are in the thousands, it seems less likely.

Perhaps understandably, much of the focus for development in agricultural technology appears to be targeted at developed economies where the key drivers can be characterized as lowering labor cost and increasing productivity from a limited land area.

The influence of strong regulation in many developed nations further emphasizes the need for innovative solutions to agricultural challenges. However, despite the desire to lower operational expenditure (via labor cost reduction), many farm owners lack the capital to make significant investments viable; large scale automation systems are inaccessible to all but the largest corporate entities.

In the past, access to new technology may have been available on a rental or cooperative ownership basis: this reduced the expenditure for each farm as there was no need to spend on tools which might only have been used for a small number of days each year.

The current leading technology developments for sensing ground state, irrigation control, or fertility prediction assume year round deployment to show their benefits; the systems must be purchased or leased at high cost by each and every farmer. Instead, new technologies could be deployed to the field by a service model, where the farmer pays for the knowledge gained, treatment provided or the results based on increased yields, rather than directly purchasing the underlying technology.

Technology themes

In order to deliver on the seemingly infinite promises of agri-tech, we are seeing three key themes in new product and technology development: monitoring, automation, and precision.

Across arable and pastoral farming communities, delivering new products in these categories – or transferring technology from analogous industries – should lead to immediate productivity gains and lowered OPEX to the end customer (i.e. the farmer). Each of these themes presents its own historical context, challenges and ultimate potential solutions; it is key that these are appropriately considered at the outset of a product development.

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Automation

Automation is nothing new to the agricultural industry: prior even to the industrial revolution, innovations like the plough and Jethro Tull's seed drill have helped farmers optimize their land use and improve yields.

There have been regular changes to the way we automate manual labor on farms driven by ever bigger and ever more powerful engines. Today, a field can be tended to largely by a single tractor driver from ploughing to harvest; though high value, delicate crops in many cases still require a manual intervention at the point of harvest. For dairy farmers, the milking process is largely automated, to the point of tracking output on a per-cow basis through RFID style ear tags.

There are a number of companies developing so called "soft robotics" systems to pick fruits without causing damage. Some of these rely on machine learning approaches, which increasingly can be used to teach robotic systems the appropriate forces and motions. Given a suitable training regimen, the robots can pick the fruit as successfully as a human worker, often utilizing snipping or suction tools in place of the manual dexterity of a human hand. The key to full automation of these processes is to couple the picking process to a suitably robust selection mechanism to identify when each individual fruit is most ready to be picked. The continued promise of automation systems is to commit zero man hours to the field; indeed, some small scale trials of such farms are underway in partnership with academic institutions.

One key question that must be asked at this point is whether or not the correct approach to automation is to replicate wholesale the methodologies by which we have optimized farming for human interventions.

In other words, should we develop automated solutions to mimic and replace the human, or instead re-engineer the growing environment to better suit the robotic systems we develop?

Developments such as hydro or aeroponic growing systems seem eminently designed around automation—minimizing machine risks related to dirt, rain, etc. For crops grown year round in greenhouses, such as berries, peppers or fresh flowers, the growing environment from soil to planter box design should be considered as potential innovation centers; if we can better present the fruits for harvest we might be able to avoid the unnecessary complications of 9-axis soft-robot arms replicating human motion. For example, Agrobot's automated strawberry harvester is assisted by arranging the plants so that the fruits hang in plain sight of the detection system.

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Fundamentally, automation in large-scale row crop environments presents a significant challenge as we must acknowledge the reality that, at some point, a machine will fail. It is absolutely key to understand the impact of a broken down robot on harvest timescales, product quality, and ultimately profit margins. After all, if a farm is required to employ a team of engineers and technicians to maintain the robotic fleet and guarantee uptime, the economic equations are not as clear cut as they may first appear.

Minimizing CAPEX should be a clear goal of any developer who wants to sell to the many thousands of small scale or family farms; one potential strategy for approaching this is to consider modular solutions. These are systems that share a common body, guidance and drive mechanisms, and power supply, but where the active component – the plough, chemical delivery system, and harvester or inspection system – could be swapped out depending on the time of year or specific need on the day. This reduces the costs associated with necessary, but non value-adding components of the system (locomotion, route guidance, power), though of course it causes challenges relating to necessary over-engineering of the base system, compromised system design and availability or redundancy in busy periods.

Monitoring

Monitoring aspects of the farm is common across the globe, whether that be through weather stations or by flying planes to get better visuals across giant corn fields. More discrete soil sensors have been available for a number of years, targeted at specific indicators of soil quality – moisture or nitrogen levels in particular. However, these have not had the uptake that technology developers may have naïvely expected, potentially due to cost per sensor, or lack of reliability and granularity on the data.

There are a number of companies exploring the capabilities of drone / UAV platforms to fly high-resolution cameras, hyperspectral cameras or other imaging systems. These systems are enormously powerful at giving large scale data on general trends in growth or ground state. However, in many cases it's apparent that to get real-time, granular information about soil qualities, it is necessary to have sensors embedded in the ground. Remote sensing is not currently able to provide a sufficient level of granularity on the parameters that we can control or affect; and UAV flying can be restricted by local weather conditions, ground topologies and regulations on light aircraft.

Monitoring technologies in theory promise to unlock higher productivity by driving smart decision making processes. By understanding better the current ground state, or better spotting challenges in the herd, it is possible to determine actions that need to be taken—any remediation for NPK levels in the soil, or callouts to the vet can be processed and recommendations made automatically by the system.

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One big problem facing product developers is the reality of transmitting data around farms. We cannot guarantee that there is line of sight between the sensors (either in the ground, or mounted on animals) and a suitable data collection "base station". Technologies like LoRa promise long-range communications but cannot transmit high data rates; it is necessarily dependent on the use case (farm size, topology etc.) that we consider how to build these technologies.

A further challenge for product developers is to consider the ways in which these sensors can present that data to the end product user—it is not enough to simply report the current state of affairs, monitoring systems must be required to provide decision support to the farmer via clear recommendations for action. Numerous consumer studies have shown that an overabundance of data only paralyzes consumers, for example, according to Miller (1956), a consumer can only process seven items at a time. After that they have to create a coping strategy to make an informed decision and this can lead to the consumer making no choice at all[2]. Technologies therefore do not necessarily empower the end user without careful consideration.

"Monitoring systems must be required to provide actionable insights to the farmer."

The flip side is that the product developers can become reputationally and contractually liable for the decision making processes. We must be aware of the potential for farms to be negatively impacted by the decisions suggested by the monitoring system; in a simple system, one can allow the farmer to make their own decisions regarding how to react to the data. As product developers continue to add complexity, and become more prescriptive in the outputs, there needs to be a plan for responses based on inadequate or partial data.

A simple example: say there is a 75% chance of rain later in the week and a proactive action is assigned for the early part of the week; there is inherently a 25% chance that the assigned action might be incorrect, or at the least, incorrectly scheduled.

Precision

Precision technologies promise the ability to increase the productivity of land whilst minimizing resource use whether that is chemical application, unproductive land, or nutritional optimization for animals. Improvements in technology can deliver yield improvements whilst also cutting operational costs in terms of wasted raw materials.

Many of these technologies will rely on improved insights from monitoring systems in order to make smart, automated decisions regarding resource use – for example making sure the right chemicals are delivered just in time for application – freeing up valuable warehousing space which might better be used for productive uses.

Precision systems are under development across the agri-tech space, from well-known examples such as the Blue River "see and spray" herbicide delivery system, numerous precision irrigation platforms such as those provided by Jain, and in-line milk analytics from GEA which can feed back data regarding the productivity of each cow.

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Of course, the agricultural industry has relied on precision operations for centuries in the form of human labor – determining 'what is a weed?' and 'what is crop?' or adjusting the feed for herds of cattle based on the day-to-day conditions or productivity.

The focus with precision systems is to reduce chemical, energy, time or space usage in order to increase productivity per hectare and decrease the cost basis associated with day-to-day operations. One key proposed benefit of precision herbicide / pesticide use is the potential to resurrect old chemical lines which are highly effective but unsuited (or banned) for widespread spraying.

Better understanding of product quality also allows for automated grading or bucketing of produce, meaning higher value gained from the best crops. Any natural product will vary from plant to plant, animal to animal, year to year; the economics therefore requires producers to guarantee a certain quantity at a certain quality, for instance, oil content in a seed crop. Precision technologies not only assist in guaranteeing that quality (by taking proactive steps through the course of production to guarantee the end result), but also by enabling a diversified marketplace for different quality product buckets.

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Ultimately, good precision systems rely both on strong monitoring and automation processes. We must be able to take in good quality data regarding the state of the crops or herd and react in a systematic fashion. It would be impossible to deploy a full precision, connected farm in one fell swoop; the costs would appear impossible for anyone to justify even if the potential upsides are as promised. Choosing a suitably scoped discrete system will be key for success, or alternatively tying the system back into other available services. Single, proven, discrete closed loops of monitoring and automation technologies will drive innovation in this sector for the foreseeable future.

Conclusions

Technology developers for agricultural purposes must be aware of the context in which they develop their solutions. It's common for start-up companies to speak of technologies causing disruption in a market but for the farmer on the ground, disruption must actually be minimized and the rewards of new products must be obvious and immediate.

At Sagentia, we see the development of technologies across the automation, monitoring and precision spaces as key to delivering valuable innovations which drive productivity and minimize operational expenditures. Our experience in – and expertise across – adjacent industries allows us to see the opportunities such technologies can offer to the agri-tech sector. By migrating some of these – such as diagnostic tools from the medical sector, or ruggedized sensors from oil and gas fields we are working with some of the leading sector companies to create solutions which are economical, scalable and provide actionable insights to the user.

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[1] Source: DEFRA, Farming Statistics, November 2018

[2] Miller, George A. (1956). "The magical number seven, plus or minus two: some limits on our capacity for processing information". Psychological Review. 63 (2) 81-97